Evaluating Silviculture Projects

Excerpts from the Literature to 1990

on Evaluating Priorities for
Silvicultural Expenditures

FOREST
RENEWAL BC

Preface

This document contains excerpts from the literature on silvicultural decision making, interspersed with introductory or explanatory notes. It is not a literature review and is not intended as a comprehensive survey of the subject area. The excerpts were selected to provide background information on topics that may be covered in the workshop but the document does not reflect the scope of the workshop nor the relative importance of the various topics to be covered in the workshop. The excerpts are from papers and reports encountered by the editors during the development of the workshop and which the editors thought would be of interest to workshop participants. Rather than simply publish a bibliography or ask the participants to read each publication, relevant passages were extracted and included in this document. The editors encourage workshop participants to read the source documents to develop a more complete understanding of each topic.

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The Nature of Silviculture Projects

Why are silvicultural projects controversial and difficult to finance?

Two general characteristics of silvicultural projects make them controversial: the long time between silvicultural treatments and their benefits, and the diversity of perspectives and objectives of the stakeholders.

Silvicultural projects are a forest management activity like forest protection and timber harvesting; they are expensive, they may involve large social, and environmental impacts, and they involve altering the forest rather than simply measuring it. However, unlike other forest management activities such as protection and harvesting, the funding of silviculture activities has traditionally been viewed as a long-term investment rather than as an operating expense.

As a long term investment, silviculture has some obvious drawbacks: it must provide a return that exceeds the opportunity cost of the capital investment, it is illiquid (there is no market for immature trees), and it is subject to substantial risks of fire, insects, and disease, to say nothing of market risk.

The second troublesome characteristic, the diversity of the stakeholders in a public resource, is equally problematic. The growing public awareness of the issues surrounding silviculture and timber supply, combined with lack of technical knowledge, plus the diverse and multiple objectives of the major players, complicates the decision making process immensely.

In the excerpts that follow in this section, we find that frequently the way we view silvicultural investments influences the goals we set, the way we make decisions, and the results or returns we expect from them. Reed (1985) makes the case that intensive silviculture is necessary to ensure continuation of the social and economic benefits that we receive from the forest, and that the traditional economic perspective of silvicultural investments is incorrect and prevents us from investing wisely. Brumelle et al (1988) characterizes silvicultural activities as having uncertain outcomes, multiple objectives, multiple stakeholders, and a hierarchy of decision-makers. The excerpt from Vaux (1967) shows how historical changes in population, societal needs, technology and legislative goals create problems for the planner attempting to make decisions about long-term investments. Raup's (1966) paper provides a historical perspective on the forces that shape the decision-making environment for the forest manager, and shows how events that have little to do with forestry directly may determine the outcome of forestry investments made decades earlier. A further excerpt from Reed (1988) argues that a philosophy of stewardship is appropriate when considering silviculture expenditures, while Coufal (1989) reviews Aldo Leopold's concept of a land ethic.

[from Reed, 1989; (precis) -- limitations of financial analysis, benefits of silviculture]
Provincial governments are far and away the owners of the largest proportion (>90%) of forest land in Canada (south of 600). The federal government contributes funding for forest management as both recognition of its share of the income derived from the forest resource as well as recognition of the less easily calculated social benefits of forest utilization.

Reed stresses that evaluation of forest-level silvicultural investment decisions based on discounted cash flows of the individual stand sorely underestimates the value of the forest. Monetary values accrue throughout society from the utilization of the forest in the form of royalty and tax revenue, export earnings, direct and indirect employment, transportation, and regional economic activity. Forest renewal and management activities also directly contribute through employment and manufacturing.

For the industrial forest owner, according to Reed, forest management activity improves security of wood supply, protection of shareholder equity, and opportunity for expansion.
In a paper on the evaluation of silviculture investments, Reed makes the following main points:

1. Timber deficits are now being experienced across Canada, especially for quality sawlogs.
2. The traditional method for evaluating silviculture expenditures (discounted cash flow) is based on short run economic efficiency concepts, which is incomplete, biasing, and suggests rates of return which are unnecessarily pessimistic. It has little to offer that is relevant in judging the merits of managing large existing forests. Reed's views on the traditional Discounted Cash Flow approach are included in more detail in this paper in the section on Financial Efficiency Criteria.
3. Longer run concepts of "conservation and wise use" must be included in such analyses.
4. The really important benefits of silviculture treatments are:
   - moving stands forward in the harvest queue
   - reduced costs of harvesting and processing
   - enhanced value of finished products
   - reduced operating risks
5. The benefits from treating existing stands of timber could be substantial. However, of the nearly $1 billion currently spent annually in Canada on silviculture, less than 3% is being directed to the improvement of middle aged stands by precommercial thinning and fertilizing.
6. Intensive forestry will mean additional volume at harvest. Intervention in stands nearing maturity will often boost them up to merchantable diameter in 10-20 years less time. The most important gains will likely result from reductions in costs and increases in product values. These flow from a more attractive species mix, larger and more uniform logs, and improved lumber recovery factors.
7. The icing on the cake may turn out to be a sharp reduction in operating risks related to (1)damage from insects and wildlife, and (2) timber supply
8. Implications for FRDA's: reclaiming backlog NSR falls way down on any objective scale of priorities except for creating employment. The enhancement of existing stands promises much larger and earlier benefits. Moreover, improvement of middle aged stands is the only approach which promises to mitigate pending curtailments in threatened communities and to open the way for expansion in others.

[from Brumelle et al., 1988; -- socio-economic considerations]
"The time horizons involved in most silvicultural investment decisions are long and the number of alternative investment strategies is very large. While there is a limited understanding of the ecology of forests, the ability to predict specific outcomes of the dynamic stochastic (random) processes which are involved is limited. The socio-economic system involved in the silvicultural investment problem is even more complex and less understood than the biological system. Decisions in silviculture involve multiple participants who may have different objectives,

planning horizons, tastes and information. These may change rapidly over time as the socio-economic environment changes. Since silvicultural investments involve long time periods, their analysis must consider not only current participants in the system but also future participants and their socio-economic environments. Shifts in employment patterns, interest rates, changes in technologies for processing forest products, manufacturing techniques, changes which affect competitive or complementary products are but a few of the socio-economic factors which may substantially change the implementation, the outcomes and the value of a given silvicultural investment.

[editors]
Forest management is a social and economic endeavour, and as such, is goal-oriented. Nevertheless, we frequently find that forest management objectives are not clear. Even when they are, they change over time - markets change, processing technology changes, and the timber resource itself changes, for example. Management objectives for non-timber forest resources are usually even less well defined, and at least as changeable.

[from Vaux, 1967: -- evolution of forest management goals]
The following excerpts from Vaux (1967) describe the development of goals as something other than a deliberately rational, conscious process. It is more like a historical evolution, influenced heavily by bias from the legislature, traditional values, and current societal need as perceived by the management agency. Because of this development of goals over long periods of time, different resources such as timber, range, and recreational potential are rarely always managed in a historically consistent manner.

"The goal of national forest timber sale policy [in 1967] is that of preserving the living and growing timber and promoting the younger growth on the national forests. But in 1905 the economic goals to be achieved through timber sale policy were identified by administrative regulations which sought to encourage efficient operators, stabilize local communities, and prevent monopoly in forest products industries. From time to time other legislative and administrative goals have been added, such as those defining the level of allowable cut from public lands, the minimum size and maximum duration of individual timber sales, and the so-called small business set-asides. These aspects of timber sale policy have influenced decision-making about public forest resources by modifying or redefining the economic goal of such decisions."

"The history of timber sale administration also shows how specific economic goals have changed. Sustained yield and community stabilization, for example, are traditional goals for selling timber so as to maximize net income to the people who are dependent on the resource. But the concept of who is dependent on a given tract of timber has changed remarkably over the years. Before 1907 products cut from national forest timber could not be exported outside the state of origin, and the concept of a working circle there in effect limited primary manufacture of public timber to an area within a few miles of its growing site. Then Congress removed the export restrictions. Technological advances increased the size of working circles on which Forest Service management plans were based. The result of these changes has been to redefine the populations that derive primary and secondary benefits from timber sale policy and thus to redefine the economic goal of that policy. Up until World War II, virtually the entire supply of California's national forests was very near the margin of profitable use, and utilization was only a small fraction of the allowable cut. The highest priority economic goal was for development of primary access to the timber and for efficient manufacture by sawmills that could operate successfully on

a narrow margin of profit. Large and long term sales were needed if there was to be any economic development of the resource."

"After the war prices rose, more people entered the stumpage market, and greatly increased funds became available for road development both from Congress and from potential timber buyers. Large size timber sales were then no longer essential for economic development or manufacturing efficiency for the survival of manufacturers. Sale policy shifted to one under which most California sales have been [relatively small and short term]. The allocation of timber appears to have been redirected toward maximizing current returns to the public treasury and encouraging competition among timber buyers, and away from the older goal of development."

"An entirely different system has governed the allocation of forage benefits from the public lands. Individuals have been granted preferences for the use of public range because they owned ranches that were economically dependent on the public range. There have been strict limitations on the maximum size of ranch unit allowed to graze, and grazing fees have varied between a substantial and a modest fraction of fair market value. This policy appears to have secured integration between private and public resources where this was necessary for efficient operation, discouraged economic concentration in the dependent livestock industry, and discouraged the entry of additional firms into that industry. The goals inherent in this policy have been just the opposite of those used in the allocation of timber."

"Still other economic goals appear in the allocation of recreation resources. Recreational uses that require exclusive occupancy of the land have been charged only nominal fees; transitory uses such as camping and hiking have been permitted free. There has been very little rationing of recreational benefits comparable to the rationing of timber through allowable cut and stumpage price policies or to the rationing of forage through carrying capacity range-allotment policies. Recreation goals, unlike those in forage and timber, make no serious attempt to influence the structure of development of dependent communities or industries. Rather the free use policy has stimulated consumer demand because it subsidizes recreation consumption wherever there is an alternative use for the lands supporting the recreation resource."

[from Reed, 1985; -- stewardship]
"Leaving aside for a moment the very important issue of economic efficiency, there is the separate and distinct question of conservation of renewable resources. The central idea here is that the resource base is jointly owned across generations. In this context the issue is equity rather than efficiency. Thus, we speak of intergenerational or intertemporal equity, where the time horizon extends well beyond that which is normally considered in corporate decision making."

"Conservation criteria are applied increasingly to publicly owned resources such as forest land. Public land managers find that efficiency when taken alone tends to bias decisions toward the short run and the present generation. There is a growing tendency therefore, to adopt a conservation stance which reflects a philosophy of stewardship..."

"Conservation on the other hand, must be distinguished carefully from "preservation". Those who espouse preservation hold that man should not intervene in the natural setting but rather let nature take her course. That is in sharp contrast to resource managers who often speak of " conservation and wise use" as their principal mandate."

[from Coufal, 1989; -- land ethic]
"More than fifty years ago, in this journal, Aldo Leopold wrote of the need for a conservation ethic. Leopold then suggested, in fact urged, that ethical considerations be extended to

relationships between man and his community. The term "land ethic" was used because Leopold included in his definition of community " soil, water, plants, and animals, or collectively , the land."...Leopold, as much as Pinchot, believed in managing the land, from preservation to intensive culture, as appropriate and compatible with the land's capabilities. To Leopold, the unifying feature in all levels of management was taking a holistic view. This included first the "land" as described above, and second a land ethic that "changes the role of Homo Sapiens from conqueror of the land-community to plain member and citizen of it". Third, the critical item, the one Leopold called the "key-log" to be moved to develop a land ethic, was his call that we "quit thinking about decent land-use as solely an economic problem. Examine each question in terms of what is ethically and esthetically right, as well as what is economically expedient". What is ethically and esthetically right may not be any more cloudy than what is economically right, especially at the extremes."

The Benefits of Silviculture

Why do we undertake silvicultural projects? The benefits of silviculture most often cited are:

- improvements in growth and yield,
- increases in the value of the timber crop,
- reduction of harvesting costs,
- reduction of risk,
- improvements to the aggregate wood supply picture,
- increase in employment,
- long term stabilization of communities, and
- social/ethical returns.

In the following sections, these benefits are examined in extracts from the literature relevant to British Columbia.

Growth and Yield

[from Fraser, 1984; -- on spacing]
"In terms of gross cubic volume growth, the evidence appears to favor the view that the growth potential of a site is fixed by the soil characteristics, availability of nutrients and sunlight (S. M. Smith, 1983). The attainment of this growth potential depends upon the degree of site occupancy. Since the environmental determinants of a site's growth potential are unaffected, spacing will not increase gross cubic volume growth. In fact, spacing is more likely to decrease gross cubic volume growth by reducing, at least temporarily, the degree of site occupancy".

"This anomalous result need not be significant. Any resulting loss of growth may be negligible, at least in light or medium spacing where full site occupancy is recaptured quite quickly. Also, a number of studies indicate that mortality declines in spaced stands due to decreased competition. As a result, the total live volume of timber in a spaced stand may increase more rapidly than in an unspaced stand. It appears likely that the total volume in a spaced stand will approach the total volume of the spaced stand over time."

"This tendency of spaced and unspaced stands to trend towards a fixed volume is well supported. For example, a number of studies of agricultural plants have repeatedly demonstrated a constant final yield of total dry weight regardless of density (S. M. Smith, 1983). In forestry, Pienaar and Turnbull (1973) tested the hypothesis that stands of different initial densities approach a common basal area per unit area. They concluded that initial densities from 1200 stems to 200 stems per acre ultimately sustain an equal live basal area per acre. This generally supports the earlier findings of European studies by Moller (1954)."

"In summary, spacing does not appear to increase the gross cubic volume growth of a stand or even its final standing volume. However, from an economic perspective, of ultimate concern is the impact of spacing on merchantable volumes. Although the total volume may not change, a greater proportion of this volume may be commercially useful. The effect of spacing is to change the growth and the growth rate of the remaining trees. Considerable evidence confirms that spacing has a direct and significant impact on diameter growth. The impact of spacing on height is less clear and tree height may be little affected by stand density. However, diameter alone is a key determinant of merchantability. All merchantability standards have a lower diameter limit. Clearly, a larger proportion of the surviving trees in a spaced stand (and consequently total volume) at harvest age will fall above any given merchantability limit."

"The potential economic benefits of juvenile spacing fall into three distinct categories. First, the merchantable volume of the stand may be increased. However, the extent of the volume increment will depend critically upon the rotation age, the productive capacity of the site, and above all the merchantability standards at harvest age. All of these factors should accounted for in projecting volume benefits from spacing. Simple statements of proportional gains from these treatments, which are often presented in the literature, are really inadequate."

[from Nawitka, 1987 – on spacing and fertilization]
"For the range of densities encountered under operational conditions in even-aged stands:

1. A given site has a fixed potential yield because it provides just so much soil moisture, soil nutrients, carbon dioxide and sunlight for plant growth.

2. Spacing or a low initial density does not increase the fixed potential yield of a site. Therefore, spacing of a low initial density does not increase potential total stand volume. In fact a spaced stand carries a smaller total volume/ha than an untreated or high-density stand for a considerable period. Eventually the total volume of the spaced stand catches up to the untreated stand. In operational conditions the spaced stand volume may eventually exceed the unspaced stand.

3. In terms of merchantable volume, a spaced or low initial density stand may not carry a reduced volume/ha and may carry an increased merchantable volume/ha for a considerable period. Eventually the merchantable volume of the untreated or high-density stand will catch up to the spaced or low-density stand.

4. A spaced or low-density stand will reach a harvestable size more quickly. If harvesting occurs as soon as the stand is big enough, then spaced and low initial density stands may yield a higher merchantable volume than high density stands.

5. Fertilization does raise the productive capacity of a site and, like spacing shortens the time to merchantable size. In forest stands a single application of fertilizer produces a transient growth response which lasts about 12 years for Douglas fir. The response peaks about four to five years after fertilization and tails off thereafter. At the end of the response period the

structure of the fertilized stand is different from the control and the subsequent development of the fertilized stand will also be somewhat different."

Timber Value

[from Fraser,1984; – piece size and clear wood]

"The impact of spacing on the unit value of timber is less clear. There are a number of positive and negative factors which must be considered. Most log markets incorporate general premiums for larger log size. This partly reflects lower processing costs, but also the higher valued products which can be produced. On the other hand, the larger trees produced through spacing have a number of technical shortcomings which could be detrimental to unit value. Only some of these drawbacks are presently reflected in the pricing system. However, in future years as second-growth timber becomes a more important component of raw material supply, the pricing system may differentiate more closely."

"One key factor is that larger log sizes are required to produce higher valued lumber and plywood products. Also, within the lumber market, larger dimension products generally command premium prices. The dramatic impact of these factors on the unit value of logs is indicated in the 1975 Crown Zellerbach study. This shows Douglas-fir log prices ranging from between $45 and $50 per cunit at a 10 cubic foot piece size to over $75 per cunit at 45 cubic feet piece size. Similar figures for western hemlock indicate a range from $45-50 per cunit at 10 cubic feet to $60 per cunit at 45 cubic feet."

"On the other side of the equation, thinning tends to stop natural pruning and stimulates the development of large branches. Consequently, the trees from spaced stands will tend to produce logs with larger and more frequent knots. Size and frequency of knots is another key factor in log grading with substantial premiums paid for "clear" wood. As indicated by comparison of Tables 2 and 3, there is a several hundred dollar difference between the price of clear lumber and dimension lumber of the same width. The increased knottiness of wood from spaced stands may be a significant offset against the higher value from increased log size."

"In addition to this, there has been some concern expressed about other quality elements of fast grown wood. Logs from spaced stands will have fewer rings per inch and close grain wood is required for a number of specialty items such as select structural scaffold planking and the top grades used for interior and exterior trim, cabinet work, etc., where fine finish is important. Also, there is some concern about the specific gravity of the wood. This could reduce pulp values and the strength and stiffness of lumber products (J. H. G. Smith and Robt. W. Kennedy 1983). However, it seems to be generally accepted that commercial losses due to these factors will be relatively small in relation to the commercial gains from increased tree size. Smith (1977) concludes on the basis of spacing trials at the UBC research forest that wide rings are unlikely to be a major problem in British Columbia while Smith and Kennedy (1983) conclude that tree volume can be significantly increased without affecting wood density to any important extent."

"In summary, most important elements of quality are piece size and production of clear wood. While spacing can dramatically improve piece size, its impact on the production of clear wood is likely negative. This disadvantage can be overcome by pruning in spaced stands. However, the economics of this treatment have not been investigated to any extent. In the absence of pruning, the overall effect of spacing on the unit value of timber produced is uncertain, particularly in the long run. Over time, many of the processing economics presently inherent in large timber are likely to diminish as processing technology gears to the smaller wood in second-growth stands.

It certainly appears likely that projecting benefits on the basis of current size premiums alone will tend to overestimate the benefits of spacing."

[from Fraser, 1984; –pruning]
"...it is possible that the larger trees resulting from spacing will command higher unit prices than their unspaced counterparts. However, projecting economic benefits on the basis of present size premiums alone will likely overestimate actual returns. Unless pruning is also applied, the spaced trees will contain lower quality wood than unspaced trees of equivalent size. Also, over the longer run, size premiums are likely to decline to some extent. A much closer look at this area is warranted."

[from Sterling Wood, 1988; -- economics of second growth]
"So called second-growth is being harvested at an accelerating rate. These stands are producing some of the highest real conversion returns in the province despite relatively low selling prices. These conversion returns are partly a function of excellent terrain and logging chance, developed transportation systems and increasingly efficient logging and milling techniques. This demonstrates the excellent financial feasibility of harvest in unmanaged stands of this size of timber, even when harvest occurs well below the presumed physical rotation age. It clearly illustrates the excellent potential for intensive forest management in immature stands similarly located. Component value relationships illustrated in our report will undoubtedly change in future but we believe these will all be upward. The already demonstrated high real conversion returns and this upward value expectation are most compelling arguments for use of a large financial optimism factor by practitioners for forecasts and projections. Data based on unmanaged second-growth stands below rotation age indicates excellent financial results. It follows that managed stands should achieve even better results."

"...it is evident that the effect of diameter on value takes place within a narrow band of log diameters from 15 to 25 cm. It is within this range that yield of lumber increases dramatically. Between 20 and 25 cm, stem values tend to plateau and then rise again on the expectation of recovering premium lumber grades on the coast and wider dimension widths in the interior."

Harvesting Costs

[from Reed, 1989]
"Benefits from Intensive Forest Management:

- value gains
- species mix improved
- lumber recovery factor raised
- grade and dimension mix enhanced
- residual chip values increased"

"The first of these [value increases] is the expected shift in species , away from hardwoods and toward spruce and pine. This will result from planting promptly, adequate brushing, conifer release and intermediate felling. The better quality, larger logs will provide higher lumber recovery factors, a more profitable grade and dimension mix, plus a richer diet of residual chips and roundwood for use by the pulp and paper sector. More of this will happen and the treated stands will be ready 10-20 years sooner."

[from Fraser, 1984; --tree size and harvesting cost]
"The influence of tree size on unit harvesting costs has been recognized for some time. However, surprisingly little attention has been paid to this in evaluating the relative profitability of forest investment opportunities. Part of the problem is that a considerable number of other variables, such as slope of terrain, stand accessibility, density of underbrush, etc., also influence the unit costs of harvesting. Consequently, it is difficult to identify the influence of tree size alone on unit costs. In addition, there is a general uncertainty whether systematic differences in unit costs due to tree size are significant relative to other variables."

"...a 1975 evaluation of juvenile spacing by Crown Zellerbach indicated a similar very significant relationship between average costs and tree size for both Douglas-fir and western hemlock. Although the specific functional relationship was not presented, graphically they showed logging costs declining from approximately $42.00 per cunit, at an average piece size of 10 cubic feet, to almost $25.00 per cunit, at an average piece size of 50 cubic feet.

[from Fraser, 1984; -- increase cost of harvesting small wood]
"...it is clear that the larger tree size resulting from spacing will generate substantial cost savings in the harvesting operation. However, it is also clear that the cost relationships are nonlinear in nature. Consequently, the harvest cost savings cannot be accurately estimated on the basis of average diameters with and without spacing. In effect, projections are required of the frequency distribution of diameters in the spaced and unspaced stand.

[from Sterling Wood, 1988; -- tree size and conversion costs]
The effect of diameter on conversion costs is relatively insignificant once the impact of value recovery has been accounted for."

[from Reed, 1989]
Benefits from intensive forest management:

Cost reductions;

a. shorten hauling distance by treating near the mill

b. produce larger, more uniform logs for logging cost savings, and for lower processing costs

c. protection costs reduced [as the] forest is harvested at a younger age [and there is] less natural mortality

Reduction of Risk

[from Reed, 1989]

a. insect and fire [are] losses reduced

b. [there is] less reliance on open market [for] for logs [and] for pulp chips

c. less risk of curtailment from timber shortage"

[editors]
It is recognized in the financial literature that there are two ways in which risk can be reduced (Brealey et al, 1984). One way is through diversification of the current portfolio. The other way is by hedging to reduce the possibilities of losses in the future. Investments in silviculture may not necessarily reduce the probability of plantation failure. However, by providing more options

for marketing the plantation yield, they in essence provide diversification in the product portfolio of the landowner. Further, higher value products can probably be carried on the stump longer than lower value products (i.e. they ought to continue to increase in value), allowing the landowner more flexibility with respect to when the stand is actually placed on the market.

Aggregate Wood Supply Benefits

It has been argued that silvicultural programs can improve the aggregate timber supply picture for a region, by delaying or preventing falldown, or by increasing the productivity of the forest to a degree that would allow an increase in the rate of harvest. A description of this strategy with reference to New Brunswick forests is presented by Baskerville (1982) and will be used here to illustrate the concepts.

[from Baskerville, G. 1982 -- avoiding falldown]
Most of the older stands in New Brunswick originated following the 1913-1919 outbreak of spruce budworm, and are now [in 1982] 55 - 65 years old. Figure 1 shows the unevenness of the age class structure.

When the stands that are currently in the 50-60 year age class have been harvested, there will be a shortage of mature timber until the stands in what is now the 20 -30 year age class mature. Therefore, for a period of about 20 years there will be a shortage of timber (Figure 2) unless some action is taken to bring the younger wood to merchantable size much faster. Figure 3 shows the wood supply available from increasing levels of silviculture. When the incremental supply resulting from silviculture is combined with the transitional forest, an increase in harvest is possible (Figure 4).

Employment

A benefit of silvicultural projects that is often cited is the injection of funds into local economies through the wages paid to silvicultural workers and the purchase of supplies.

Fraser and Howard (1987) found that about 75 cents of each dollar paid to a contractors for tree planting was for labor services, but that only 37% of the workers were hired in the area local to the project; the rest were hired elsewhere in British Columbia and Canada.

Deloitte Haskins and Sells conducted a survey to study the socio-economic impact of silvicultural employment under the 1985-1990 Canada-British Columbia Forest Resources Development Agreement. Their survey included workers in many types of silvicultural projects, not just planting, and they found that 80% of contract costs were for labour and another 15% was for equipment and supplies. Contrary to the findings of Fraser and Howard, the survey found that 80% of the workers were hired locally.

Community Stability

The argument is sometimes made that programs of silviculture will contribute to the stability of communities. This argument can be subdivided into short term and long term effects: in the short term, expenditures on silvicultural activities provide short term employment and other economic returns to a community, as would any other industrial activity; and in the long term, silvicultural investment will enable a sustainable evenflow of timber, which in turn will foster community stability.

The first part of the argument (short term effects) is easy to accept, although tricky to quantify, and will not be examined further in this section. The second part of the argument, that silviculture increases or smoothes harvest flows (see the section Aggregate Timber Supply Effects, above) and therefore enhances community stability, is less obvious. In fact, many authors question its validity.

Since the sustained yield management constraints of timber harvesting have a large opportunity cost, and that the justification for these constraints is community stability, this is an important issue.

The following readings examine the premise that a sustained even flow of timber from the forest is necessary for the achievement of community stability. Shallau (1983) and Waggener (1977) examine what we mean by the terms stability, community and dependence. Waggener (1977) goes on to examine community stability as a forest policy objective, and traces its historical development. Helfand and Emerson define community stability as orderly change.

[from Schallau, 1983; -- what is community stability?]
"The term "community" is nebulous. The Forest Service policies cannot be expected to assure economic stability for all cities and municipalities, so civil divisions are of little help in delineating the boundary of a community. ...In the past, maintaining the status quo has been the most generally accepted definition. In this regard, sustained-yield harvesting has been equated with community stability. But such a concept is inappropriate in our dynamic, ever-changing economy. Recent Forest Service guidelines define community stability as "the rate of change with which people can cope without exceeding their capacity to deal with it." This definition recognizes change as inevitable. But an objective measure of community stability based on "coping capacity" might be difficult to devise.

"Community stability is best viewed in terms of long-term (secular) change rather than cyclical change. National rather than local conditions determine the timing and duration of business cycles. Cyclical change often signals the need to reallocate resources rather than return to pre-recession conditions. For example, a surplus of skilled workers may attract a new, non-timber firm to a community. Therefore, orchestrating timber flows in order to help relieve economic problems related to the relatively short business cycles might not be appropriate in light of a community's long-term economic potential.

[from Waggener, 1977; -- the meaning of community stability and origin of the concepts]
"Stability. - The concept of stability as used in forestry has many meanings. The most common, perhaps, is the notion of constancy - an unchanging value for some independent measure. An even flow of wood output or constant prices or employment are such interpretations. ...The absence of sudden and unpredictable changes in output or price is often identified with stability. Yet another concept relates to the degree of short-term variability about the trend of the selected variable over time.

"Community. - A clear idea of what constitutes a community is necessary in the assessment of stability as a policy objective, but the literature is lacking in any explicit definition. Early forestry history indicates the idea of a closely knit social community almost wholly isolated geographically and economically. In today's economy, however, the concept of community is neither clear nor simple. Political, geographic, social, and economic aspects of community are no longer coincident, and their divergence is a fundamental source of ambiguity. As economies of scale in production and transportation have changed, the concept of an economic community has

altered greatly. ...The Forest Service focus for community stability is now the planning unit - normally a national forest in lieu of a specific local community.

"Dependency. - Dependence is relative, and can seldom be defined precisely. If there is any functional relationship between a community and the forest, there is a degree of dependence.

"The origins of concern for community stability can be traced to the middle of the 18th century in northern Germany. The virtually undeveloped state of transportation and communication resulted in a widespread system of small, independent political units with high customs barriers that prevented any significant degree of regional trade. Local consumption depended directly on local production. Self-sufficiency was the rule, and the effect on forestry was the development of small units where production and consumption were closely regulated. The idea of the" normal forest" became firmly established as the basis for management under the stagnant, closed economies of the period.

"The industrial revolution drastically changed the economic situation for forestry. With development of transportation and communications, each forest community was no longer required to be self-sufficient. Capitalism became the dominant economic system. Along with other goods and services, wood became an ordinary economic commodity. Nevertheless, the concept of the dependent community and the need of the closely regulated local forest essentially survived. This philosophical basis for forestry was transferred to North America, resulting in a system of management largely "inconsistent with our forest biology and our forest economy" (Behan, 1966)"

"In an industrial society, continuous consumption is not necessarily dependent upon local community production."

"Early German forestry largely dealt with the problems of unregulated use of the forest as a common property within an economically undeveloped society. There was a possibility of exhausting timber resources unless collective use was strictly controlled. As forest enterprise expanded in this country, economic conditions were totally different, but the consequences of rapid utilization appeared very similar to what had been experienced 150 years earlier in Europe. The cut-out-get-out history of industry migration, and the economic consequences for the remaining communities, were in all appearances the same. This country had faced a large economic surplus of timber and a restricted market which together made investment in permanent timber operations uneconomic. The problem was one of adjusting timber inventory to an economically optimal level while markets were developing. Nevertheless, policies were adopted on the basis of the European experience under the presumption that the causes of the observed events were the same. The assumed policy solution was that the abrupt and often dramatic changes in forest industry structure and location could be prevented if timber were continuously available for production within the local community. The linkage of sustained-yield and even-flow policies with community stability was the natural consequence. The policy implications were two-fold: that a continual (constant) volume of timber was required, and that this timber should flow to local community mills rather than to more distant mills. A balance between local industry capacity and timber production was thought to be highly desirable.

"...forestry operates in a dynamic and unstable economic environment. A major cause of this instability is the cyclic nature of demand for products and the changing economics of products technology and transportation. Stability, defined as constancy, often represents a misdirected policy designed to alleviate the more obvious symptoms of economic change.

"Economists recognize that the full employment of resources necessitates their constant reallocation from less productive to more productive uses. The process often requires geographical shifts in resource use within broader economic communities. Further, as patterns of demand, factor availability, technology, and transfer costs change, structural aspects of particular industries will inevitably also change. ...Economic stability as a dynamic concept is characterized by modulated variation. The system does not self-destruct. Policy seeks to minimize the variance or the dynamic rate of change - or both. When formulated in this context, economic stability can be viewed as the basis for economic growth. Further economic stability can be and often is in conflict with community constancy."

[from Hefland and Emerson, 1983; -- stability as orderly change]
"In the context of national policy, community stability is perhaps best viewed as a process of orderly change that allows resources to shift smoothly from less productive to more productive uses. Although the government may intervene to ease the transition, the structure of particular industries and local communities will inevitably change. Indeed, a timber-based economy, susceptible to fluctuations in market demand and technological change, is not likely to be stable even with constant timber production"

[from Byron, 1976; -- community stability and sustained yield]
"Under what circumstances would this scenario [community stability derived from sustained yield] be appropriate? Firstly, there should be uniform demand for the product - there should be no business or construction cycles or changes in export markets. Thus either a world of no trade and local self-sufficiency or participation in stable export markets would be appropriate. Secondly, there should be no technological changes in processing and no substantial changes in relative factor prices, since changes in factor proportions or output coefficients in logging and processing would, among other things, upset the requirement for a stationary labour force (or if the population of the village is to grow, then technical change should lead to greater labour intensity). Thirdly, to maintain this scenario, there should be no changes in transportation technology or costs, or in the location of transport routes. Any of these could influence the economies of localization or urbanization to be gained through relocation of the village mill.

"...unemployment in those occupations associated with the forest industry is highly unstable, that this instability is largely due to changes in the export price of lumber, and that the instability is amplified throughout the regional economy particularly where the forest industry forms the economic base of communities."

"The British Columbia Forest Service and the forestry profession generally have argued that sustained yield regulation of forests is both necessary and sufficient to assure employment stability, the permanence of communities and the conservation of the resource. The first two of these claims have been shown to unsubstantiated, while the third has been proven elsewhere (Haley, 1966 and Samuelson, 1974) to be correct but inefficient."

"Since one of the foundations for government intervention through yield control was (and allegedly still is) stability of incomes and employment, and since this is not achieved while lumber sales are erratic and volatile, lumber market intervention seems at least as justifiable as the existing regulation of supply. That is, stability of production and employment might be obtained by an agency which would stockpile inventories during depressed market periods, for resale later."

Social and Ethical Benefits

"It seems from a general survey of "successful" or "stable" mill operations that it is the aggressiveness of marketing coupled with managerial expertise that has stabilized employment, rather than even flow or any other yield regulation."

"... the third strategy [to provide short run stability to local economies] is to buffer the exogenously induced changes in demand. Those firms with strong financial backing can afford some inventory buffering and can often also rely on strong sales promotion networks. However, for the many independent and/or financially constrained forest companies in British Columbia, an organization capable of absorbing or dispersing the market risk and storage costs of holding inventories during depressed markets seems necessary."

[from Schallau, 1989; -- sustained yield and community stability]
"The passage of the Sustained Yield Forest Management Act [1944] established a philosophical framework that rested on a neat equation: sustained yield ensures community stability, which (it implied) ensures the happiness and well-being of timber-dependent towns and the people in them. But viewing sustained yield as a universal solution for all forest resource policy issues is simply not appropriate today. Simply stated, sustained yield of timber from national forests cannot ensure community stability."

"David T. Mason ...saw sustained-yield management as a means of discouraging small, undisciplined operators, mainly in the South, from moving to the West to cut and market public timber and thus drive prices down. Mason believed a sustained-yield policy for public forestlands would help shift lumber from a buyer's to a seller's market by withholding from cutting a moderate quantity below what the market would readily absorb.

"...[sustained yield in practice] has not taken into account all public and private harvest. This lack of coordination had the destabilizing effect, in the Northwest, of attracting more milling capacity than could be used in the long run - the very situation Mason had wished to avert."

It has been argued that silvicultural programs have social and ethical benefits for the population of a region. Reed (1989) suggests that silviculture programs can increase the aggregate timber supply for a region and hence reduce the pressure on existing old growth. The old growth spared by such a program would provide "non-use" benefits, as described by Brumelle et al.(1988). Power (1983) points out that we derive non-market "environmental goods and services" from a well managed forest.

Finally, it should be recognized that as part of the general publics growing environmental sensitivity, many people receive satisfaction from the knowledge that public funds are spent on stewardship of the forest.

[from Reed, 1989; -- silviculture concentrates production]
"...Also important for strategic planning is the prospect of lessening the tension over reallocating forest land to preservation and recreation categories. This positive result could be realized where there is a potential to increase the total available supply of industrial timber, thereby increasing the size of the pie rather than simply quarreling over the existing one. It ceases to be a zero sum game.

[from Brumelle et al, 1988; -- non use benefits]
"One class of benefits which rarely receives much attention is non-use benefits. We have already identified commercial option values as one benefit of this type which is actually reflected in

market transactions. There are, however, non-use benefits which are not reflected in market processes.

Krutilla has identified three classes of non-use benefits: (1) option value, (2) existence value, and (3) bequest value. Option value is reflected in willingness to pay for retaining an option to use a resource in the future which cannot be regenerated at that time and for which no close substitute is available. Existence value is the value derived from the knowledge that the resource exists in its specific form even when one does not desire to use it or be exposed to it. Bequest value is reflected in a desire to leave one's heirs an estate. These types of benefits are of significant value when one considers investment in and management of the public forest. Politically, the desire to ensure that future generations will have access to a variety of aspects of the forest resource, the need to preserve and enhance the resource in particular regions to provide the option of its use in the future, and the value that Canadians place on just having forests are potent forces that need to be considered by those evaluating investments in silviculture.

[from Power, 1983; -- environmental goods and services]
"The emphasis on job- and income-related measures of community stability is an extension of a "shorthand" assumption that defines economic well-being in terms of money income and the jobs which generate money income. ...Money income alone is not an accurate measure of economic well-being, and economics is more than the study of dollar flows and relationships. Some of the real goods and services available to individuals cannot be bought and sold on the market, and it is difficult, if not impossible, to define their monetary value. However, if the effects of timber harvest policies on these goods and services are ignored, community stability becomes a misleading and biased tool that distorts the measure of the local economy's health and emphasizes timber harvest rather than other uses of the forest."

"We do indeed regularly "eat the scenery" in the sense that the natural environment provides us with basic necessities that make life both livable and attractive. The nature and importance of non-marketed resources provided by the social and natural environment are similar to the qualities we purchase through the market. We make similar economic efforts, expending time, money, and effort in the pursuit of non-marketed qualities."

"Our economic welfare, then, is determined by a set of variables:

- The money income we can earn in a particular location.
  The cost of living in a particular location.
- The quality and character of the community in which we locate
- The quality and character of the natural environment in which we locate."

"The economic stabilization of a community cannot focus only on jobs and income. The natural and social environments contribute directly to economic well-being by providing valuable goods and services which are crucial to the maintenance of a high standard of living. Environmental goods and services are as "economic" in character as marketed goods and services, and are no more "aesthetic" or "subjective" than those goods and services sold on the market. ...analysis of community impacts and community stabilization must integrate the environmental analysis into the conventional economic analysis. If this is not done, there is a very real potential for faulty decisions that could subvert the original policy objective - to stabilize communities."

Financial Analysis

The term "financial analysis" refers to the type of analysis that estimates the commercial profitability of a project. A financial analysis is carried out from the point of view of a private enterprise determining the monetary returns from the investment of funds in a project. A financial analysis also provides information on cash flow: that is, the schedule of outflows and inflows of funds to the enterprise. Since the cash flow analysis component is essential for the budget planning process of public agencies as well as private enterprises, financial analysis is relevant for public projects. However, the profitability component of the analysis is of limited utility.

The theory and practice of financial analysis to be presented in this workshop will be drawn largely from Fraser et. al. (1977), while the readings compiled here will cover topics of special interest to the BC situation.

Interest Rates

The excerpts from papers included in this section pertain to the topic of discount rates. Nicholson (1966) reviews the observations of other authors on Treasury Board Guidelines on discount rates while Heaps and Pratt (1989) argue that a lower rate based on the real yield of government bonds should be used.

[from Nicholson, 1986]
"Benefit-cost analyses require establishment of an appropriate interest rate for use in discounting values back to the present. Fraser (1985) cites the Federal Treasury Board Guidelines as suggesting the use of a range of discount rates, including 5%, 10%, and 15%, but uses only a 5% to 10% range in his evaluation of forestry investments. Heaps (1985) states that B.C. has adopted a 10% discount rate with requirements for sensitivity analyses at 8% and 12%, but adopts a 5% real rate for the base case based on work by Row et al (1981). Heaps also provides a brief discussion of the factors that should be considered in choosing an interest rate.
"A point worth some thought with regards to interest rates is that the provinces tend to set rotation lengths on the basis of physical rather than economic criteria. This practice implicitly uses a zero interest rate. For benefit-cost analyses to be consistent with this practice they would also have to use a zero interest rate."

[from Heaps and Pratt, 1989]
"Current government guidelines for conducting cost-benefit analyses of public sector investment proposals... recommend that a real social discount rate of 8 to 10% be used... Most proposals to invest in silvicultural projects would be rejected under these guidelines."

"The analysis presented in this paper shows that the use of the current guidelines will lead to a systematic undervaluation of the net social benefits of long duration investments in forestry."

"Current estimates of the real yields on government bonds should be used as a discount rate when screening investment proposals in silviculture (historically this has been between 3 and 5%). The existence of risk and uncertainty should not be used as a rationale for undervaluing the net economic benefits of silvicultural projects by using a risk adjusted discount rate."

Discounted Cash Flow

The following excerpt from Reed (1989) criticizes the discounted cash flow criteria for determining the profitability of a forestry project which was introduced to forestry by Faustmann. Reed's argument is summarized the editors.

[from Reed, 1989]
"The selection of forestry investment criteria has spawned a considerable literature, almost all of it doggedly pursuing the Faustmann approach and applying it to entire forests. The problem here is the inappropriate use of the legitimate Faustmann idea. That stand management concept is exactly the right way to discover which of two silviculture practices, for example, planting or thinning, is the most cost effective way to deliver an additional 20 m3 on a given hectare. Applying the concept to a small stand, and then interpreting the result to the level of the whole forest, assumes that all the benefits of the treatment are captured on the treated ha. That is a false assumption which denies the other concept of forest management, which relies on the idea that the whole can be greater than the sum of its parts."

The table below summarizes Reed's contrast of the "Faustmann approach" with his view on an appropriate scheme for evaluating forestry investments in Canada today.

Faustmann's Assumptions:

Assumptions for modern Crown Forests

- start with bare ground
- start with an existing forest
- consider a single stand
- consider a forest (many stands)
- capitalize long term silviculture investment
- silviculture is a cost against current harvest
- wait till end of rotation for benefits
- benefits may accrue early through ACE
- woodlot stands alone as a profit centre
- forest is part of a larger enterprise
- only benefit is incremental volume
- benefits also include lower costs, higher value, reduced risk

"It is not intended to denigrate the notable contribution of Faustmann. There are still situations where the discounted cash flow evaluation is the only sensible way to gauge the wisdom of a silviculture investment. For example, a larger non-industrial holder of timber land or an integrated company which buys bare land for plantation purposes would be foolish indeed if a calculation of the rate of return were not made by this traditional method. However, when you have a large forest already in place, the correct question is not, "Shall we invest in a new stand on a new clearcut?" Instead, we should be asking, "Are we going to liquidate an entire forest as a valuable capital asset, or live off the annual increment of the forest?" If the answer is to live off

the increment, then the appropriate analysis is to discover the silviculture regime that maximizes the annual increment of the whole forest. In projecting the outlook for coming decades, the question becomes, "Are there some attractive opportunities to enhance the value of the forest which is already in place?" "

[editors comments]
The most important parts of Reed's argument are ;

1. Should costs be considered an investment or an operating expense?
2. How do we evaluate the importance of non-timber components of the forest and the effect of silvicultural treatment on them?
3. What is the contribution of the treatment to the profits of the entire enterprise? This is particularly difficult when the treatment is applied to Crown lands - is the entire enterprise a TSA, a District, a Region, the Province, or the Country? Are the economic benefits simply stumpage revenue, or do they include all the other direct and indirect benefits?

Stand Models Used in BC

The excerpt from Nicholson (1986) describes the stand models TASS, SPS and Prognosis which are currently used in B.C. to estimate the biological response of silvicultural treatments.

[from Nicholson, 1986]
"TASS [The Tree and Stand Simulator, developed by Mitchell] is an individual-tree distance-dependent model of tree growth (Mitchell, 1975). TASS simulates the growth of individual trees through detailed modelling of crown growth as a function of internal growth processes, competition with neighboring trees, site quality, cultural practices, damage by natural agents and genetic variation between trees (Mitchell and Cameron 1985). The current version of TASS was initially calibrated for managed stands of second-growth Douglas-fir in coastal B.C. but has been extended to lodgepole pine in interior B.C. and is being extended to white spruce (Mitchell and Cameron 1985)."

"TASS requires input of detailed information on the stand to be modeled with this information including species, site index, age, dimensions of the area being modeled, number and spatial distribution of stems, and timing, type and intensity of treatments (if any). its output provides detailed tree and stand statistics and crown maps. Experimentation has shown that TASS is able to model the impacts of initial density and distribution of trees, thinning, fertilization, pruning, defoliation, and deer damage."

"The strengths of TASS are: its ability to reliably model stand growth and impacts of various treatments on stand growth; its ability to model situation outside the range of its data base; and the detail provided on the physical characteristics of the stand at harvest. Weakeners of the model, [from the point of view of Nicholson's study] are: it needs to be run on a fairly powerful computer; it uses a lot of CPU time, with its time requirements increasing with some treatment options; it is relatively expensive to run (if computer time is charged for); it requires a great deal of information as inputs, most of which is not carried in normal inventories; and it has not been calibrated for all the major species and regions in B.C."

"SPS [The Stand Projection System, developed by James Arney] is an individual-tree distance-independent model (Arney 1985). SPS simulates the growth of single species or mixed species

stands as functions of site index, age, crown competition factors, crown ratios and initial stand conditions - either in the form of stand tables or stand averages by species (Arney 1985). SPS was initially developed for coastal Douglas-fir in Washington and Oregon and has been extended to western hemlock, western red cedar, noble fir and red alder for coastal areas and to Douglas-fir, grand fir, western larch, ponderosa pine and lodgepole pine for interior areas. SPS requires input of site reference species, site index, initial age, geographic location, merchantability limits, initial stand conditions, stand origin, treatment timing and intensity and an indication of clumpiness. The model outputs stand tables and average stand values for diameter, trees per acre, height, total and merchantable volumes, and number and diameter of logs. SPS is capable of modeling differences due to stand origin, initial stocking levels, stocking controls and fertilization of Douglas-fir."

"Strengths of the model are: its ability to model multiple species for both coastal and interior locations; its simplicity which facilitates calibration of the model to areas outside its data base; its ability to utilize inventory information in defining starting conditions; it is able to model situations outside the range of its data base; it can be run on either mainframes or microcomputers; and it provides detail on stems by diameter class at harvest. Weakeners of the model [from the perspective of Nicholson's study and in 1986] are: it has not been calibrated for B.C.; its current representations of species other than Douglas-fir are fairly crude (Pers. Comm. Arney); and it has been developed recently and has not been thoroughly evaluated and validated."

"PROGNOSIS (Stage 1973) is an individual-tree distance-independent model of tree growth. For a given geographical area, PROGNOSIS first predicts diameter growth as a function of initial diameter, crown ratio, crown competition factor, basal area of larger trees, habitat type, slope, aspect, elevation and then predicts height growth as a function of diameter growth (Booth 1984). PROGNOSIS was developed for use in the Northern rocky Mountain region of the U.S. and has been calibrated for the Inland empire area, central Idaho and eastern Montana. it can be calibrated for other regions through the use of scale factors. However, changes must be approached with caution and may require re-estimation of model parameters. PROGNOSIS will model the growth of mixed stands of lodgepole pine, western red cedar, western hemlock, Engelmann spruce, subalpine fir, grand fir and mountain hemlock."

"PROGNOSIS requires input of habitat type, age, elevation, latitude, slope, aspect stand area, sample design information and detailed tree data from a representative sample from the stand under consideration including species, diameters, crown ratios, radial increment, and plot expansion factor (Hann and Riitters 1982). The output from PROGNOSIS includes information on average stand diameter, number of trees, basal area, and volume and, for each tree, diameter and height. The model can currently simulate the impacts of stocking control and could simulate other treatments and the impacts of pests or diseases through modification of existing modules or the development of new modules."

"The strengths of PROGNOSIS are: its ability to model complex, mixed stands; its ability to be extended to other areas with scale factors and multipliers; its ability to accept inventory information as input; its ability to calibrate itself against the input inventory information; and the detail provided on the stand and individual trees at harvest. The weakeners of PROGNOSIS, from the point of view of this study, are: its dependence on habitat types developed in the Northern Rocky Mountain Region rather than site index; its need for information on the sample design used in the inventory; the detail required in the inventory information; excessive run

times on microcomputers (0.5 hr/run, pers. comm. Arney); and the potential need for major recalibration of the model if it is extended to area that differ significantly from its data base."

Uncertainty and Risk

The long period of time between incurring the costs associated with a silvicultural treatment and receipt of the treatments benefits exposes a silviculture project to risk and uncertainty.

In the excerpts below, the difference between risk and uncertainty is explained, and two approaches to the treatment of uncertainty are discussed: sensitivity analysis and risk adjusted discount rates.

[from Payandeh and Field, 1985 -- definition of risk and uncertainty]
"In statistical theory, a distinction is made between risk and uncertainty. Risk situations are defined as those in which the probabilities of the outcomes are known or can be estimated. Uncertain situations are defined as those in which probabilities cannot be determined for the outcomes. No such distinction between risk and uncertainty will be made here. Generally, the greater the dispersion of the cash flow estimates, the greater the risk. What will the average price of a cubic metre of black spruce pulpwood be in 50 years? Most managers would say truthfully, "I don't know". However, investment decisions must be made today on the basis of uncertain future costs and returns. Even though the future stumpage is unknown, it may be possible to specify a distribution of future prices. Such estimates are, of course, subjective. They are based on a knowledge of past trends augmented by intuitive feelings about the future."

[editors -- sources of uncertainty]
Dealing with uncertainty in forest management planning decisions requires a careful evaluation of the sources of uncertainty peculiar to forestry. Imagine that a forest manager, in an effort to determine which treatment regimes to assign to the various stands in his forest, decides to simulate different strategies, and to choose the combination of programs that realizes the highest value for the forest of some chosen objective criterion (e.g. PNW, physical yield). Where in the decision process is there likely to be uncertainty?

In the objectives: Forest management is a social and economic endeavor, and as such, is goal-oriented. Nevertheless, we frequently find that forest management objectives are not clear. Even when they are, they change over time -- markets change, processing technology changes, and the timber resource itself changes, for example. Management objectives for non-timber forest resources are usually even less well-defined, and at least as changeable.
Rather than using utility theory to deal with this uncertainty, a better approach may be, "to explore the implications of a wide range of possible goals without specific reference to the probability that any one of those goals will be used" (Holling 1977). This is done by testing the sensitivity of each policy to changes in management objectives. Marshall (1986b) refers to this problem as being caused by changes in the actual state of the forest and simultaneous changes in the desired state. Thus factors both internal and external to the forest cause uncertainty in managing it.

In the assumptions: This category includes two types of assumptions; those that are related to the stand level aspects of the model, and those that are related to its forest level aspects. Stand level assumptions could include biological (e.g. response to treatment), and technological (e.g. harvesting techniques) characteristics of the model. Forest level assumptions could include management objectives (designated products), management policy (e.g. sustained yield

management), technical (e.g. road access), technological (e.g. wood processing technology), economic (e.g. wood supply available outside the management area) and social (e.g. labour force) characteristics.

In control errors: This uncertainty results from being unable to actually carry out the chosen alternatives as prescribed. Control errors will be significant to the extent that the consequences are sensitive to the level of the chosen alternative activity. For example, an optimal solution might include thinning some types of stands to 600 trees/ha. How sub-optimal will be the consequences if the stand is thinned to 400 trees/ha because of operator error?

Such errors will usually be stochastic, and in long term planning ought to have relatively little impact. In shorter term plans, uncertainty in control errors can be handled with sensitivity analysis by testing the impact on the performance of the system of deviating from the prescribed policy (Holling 1977). Peterman's nomograms provide a graphical tool for doing so; selection of policy points where the response surface is relatively flat will mean that the policy will be relatively insensitive to control errors.

In the biological model: Modeling a forest stand requires dynamic depiction of its development. Handling uncertainty in stand development patterns involves estimating the range of results obtained by letting the model parameters take on the full range of possible values.

[from Payandeh and Field, 1985 -- definition of risk and uncertainty]
"There are several methods of adjusting for risk in long term investments. The most common method is to use a risk-adjusted discount rate defined as $r=i+p$ where r is the risk adjusted rate, i is the interest rate and p is a premium for risk. This approach is based on the premise that risky cash flows are worth less today than certain cash flows and must therefore be discounted at a higher rate. There are two problems associated with the use of risk-adjusted discount rates. First, it assumes risk is compounding over time. Second, there is no real basis for choosing the appropriate adjustment factor."

"Another way to cope with risk and uncertainty involves the use of subjective probability distributions. This method recognizes that the basic cause of risk is the variability in the expected future cash flows. Subjective probability estimates may be used not only to account for risk and uncertainty, but also to quantify an expert's opinion augmented by intuitive feelings about the future outcomes. Several probability distribution functions such as Normal, Gamma, Beta, and Weibull have been used for this purpose."

[from Treasury Board. "Benefit-Cost Analysis Guide"]
"Our general advice to the analyst as how to treat uncertainty is... ...to avoid concealment and to present quantitative indicators of its importance whenever possible. In some circumstances the analyst may be able to derive probability distributions of uncertain outcomes from past events... In other circumstances, the best quantitative indicators available may simply be subjective probability estimates derived from the best guesses of experts."

"Regardless of the source of information, however, there are some circumstances in which the analysts' job is completed when the relevant information has been assembled and presented to the decision-maker. Thus, where the viability of a single project or the relative rankings of alternative projects are affected by considerations of uncertainty, the task of pricing uncertainty is clearly the preserve of the decision-maker."

"There are other circumstances, however, in which the analyst can lighten the load of the decision-maker by pointing out that further attention to the problems created by uncertainty is

irrelevant to a decision. It may be that ...foreseeable contingencies will not alter a decision that a project should be accepted or rejected. Or, where alternative courses of action are being considered, examination of uncertainty may reveal one course of action to be dominant, that is, the best in all relevant circumstances. A quick search for dominance by the analyst is clearly a time-saving procedure. [There is a] short-cut method called sensitivity analysis of establishing whether this desirable characteristic is present in an investment decision."

[Gunter & Haney, 1985; -- sensitivity analysis to handle risk]
"Another method for taking risk into account is that of varying key investment inputs to examine the effect on projected results. If a small change in a key input variable produces a significant change in expected results, the outcome of the analysis is "sensitive" to that particular variable. In preparing a sensitivity analysis a uniform band of values around each variable can be tried if expected results are uncertain. However, if some pertinent information is available, investors can analyze the results for their best guess, a pessimistic and an optimistic outcome."

[from Gunter & Haney, 1985; -- risk adjusted discount rates]
"Risk-adjusted discount rates [are a] procedure commonly used for taking forestry risk into account [by making] adjustments in the discount rate. The adjustment is based on investor's tradeoff between risk and return. As risk increases, higher returns are required to compensate the investor for additional risk. For example, an investor may require an additional 2 percent as a "risk premium" for expected losses from natural hazards or business adjustments over the life of the rotation. A risk-adjusted rate is a theoretically valid procedure, if risk is perceived to be an increasing function of time."

[from Treasury Board, 1977; -- risk adjusted discount rates]
"This practice of using the discount rate to allow for uncertainty in project evaluation has limited validity. In effect, it implies that uncertainty compounds itself at a fixed rate over time. This is unlikely to be the case. Where different degrees of uncertainty can be ascribed to future values of variables, it is preferable to let estimates of future annual benefits and costs reflect these different degrees of uncertainty, and to aggregate present values using a riskless discount rate."

[from Brealey, R. and S. Myers, 1984; -- risk adjustments]
"It is usually reasonable to assume that risk increases at a constant rate. For example, if you are willing to accept that beta [variance] is constant in each future period, then the risk borne per period will be constant but cumulative risk will grow steadily as you look further into the future....any risk-adjusted discount rate automatically recognizes the fact that more distant cash flows have more risk. The reason is that the discount rate compensates for the risk borne per period. The more distant the cash flows, the greater the number of periods and the larger the total risk adjustment."

[editors]
Note that Brealey and Myers are talking about a different type of situation than is the Treasury Board, which is why they seem to disagree. Brealey and Myers are looking at a situation where risk is present and perhaps constant in every period, such as when considering investing in stocks for a long term. Treasury Board, however is considering investing in projects, which probably have discrete periods of risks of different kinds and magnitude. So why do Gunter & Haney agree with Brealey and Myers when they are clearly talking about projects? Consider that risks in forestry can be classified as either of two distinct kinds. First is the risk of catastrophic destruction to which all stands are subject. For example, fire may strike over a broad area, affecting many of the stands in the area. Such risks will be present throughout the life of the stand. The second type is the unique risk of failure to which any individual stand may succumb.

An example is a plantation, where such a failure is attributable to site characteristics, and usually is present only during the establishment period of the stand. We interpret Gunter and Haney as considering only the first type of risk, which is why they say that the use of a risk-adjusted discount rate is acceptable practice. In most instances however, any individual project is likely to be subject to both types of risk to some degree. The main point is that the analyst must carefully consider the nature of the investment and the type, the amount, and the longevity of the risks involved.

[from Heaps and Pratt,1989; -- risk of planting failure]
"A simple example should serve to demonstrate what is wrong with using a risk adjusted discount rate. Suppose that there is a risk that a planting will fail but after five to ten years this risk is resolved in the sense that the outcome is now known. Applying a risk adjusted discount rate to the returns from the final harvest assumes that the same degree of risk is incurred in each year from planting to harvest. This assumption is clearly false and unfairly biases decision makers against projects whose returns take a long time to be realized."

"The basic procedure that has been suggested for dealing with risk is that expected net present values (ENPV) should be used in determining which projects are worthwhile or which projects are most valuable. The expected net present value is calculated by first computing a net present value for the returns and costs associated with each possible outcome and then taking a weighted average of these NPVs where the weights are the probabilities associated with each outcome. Then, because decision makers are thought in general to be risk adverse, it is recommended that the discount rate used in these calculations be somewhat above the risk free discount rate..."

Economic Analysis

An "economic efficiency" analysis is in a sense a generalization of the financial analysis concept, in that the analysis is carried out from the point of view of society as a whole rather than a specific enterprise. The economic analysis is also concerned with profit, but from society's point of view -- society's wants for goods and services.

The basic concepts of economic analysis to be presented in this workshop will be drawn largely from Gregerson and Contreras (1979) and the Benefit-Cost Analysis Guide of the Treasury Board of Canada. In the excerpts below, Nicholson (1986) considers the problem of assigning costs to silvicultural projects, while Veeman (1986) and Marty (1975) argue for analyses with a wider perspective than conventional financial and benefit-cost studies, while Shuster (1980) calls for evaluation of the distributional consequences of forestry projects.

[from Nicholson, 1986; -- shadow pricing the inputs to silviculture]
"Private firms do not normally worry about the overall social costs and benefits of a project and use market prices for factors of production and products in benefit-cost analyses. Fraser (1985) suggests that public agencies must be concerned with overall social costs and benefits. He suggests that it might be appropriate to shadow price the costs of factors of production, labor in particular, at below their market values; that it is appropriate to calculate pecuniary benefits from the market price of the products; and that non-pecuniary benefits and costs - such as employment of minorities or environmental degradation - be identified and presented as additional information separate from the benefit-cost analyses. Fraser points out that current market conditions - unemployment rates in particular - should not be projected too far into the future and suggests that shadow pricing be limited to the near future with full market values used for costs incurred later in the planning horizon."

"It is argued here that public benefit-cost analyses use market values rather than shadow costs. The reasoning behind this suggestion is that: the analyses should be consistent - if shadow prices are used they should be used everywhere; shadow values are hard to determine in the present, let alone in the future; and the use of market prices is a conservative estimate in that it will tend to overstate treatment costs."

"It is appropriate to separately determine the non-pecuniary benefits and costs and to present these findings to the decision-maker together with the results of the benefit-cost analyses."

[from Veeman, 1986; (precis) -- resource allocation]
Specific Rules for Efficient Resource Allocation

1. Take a social perspective:

- include benefits/costs which don't accrue to the private sector
- consider economic activity linked to the project (e.g. sawmill...)

2. Consider extra-market values:

- some values must be imputed (e.g. shadow prices) while some can only be included as qualitative factors; nevertheless, they should be included

3. Sometimes, no use of a natural resource may be the best use

4. Avoid irreversibility in renewable resource use

- welfare economics and applied tools like benefit-cost analysis do not readily account for the welfare of future generations.
- arguments have been made for strategies that would avoid irreversibility (critical zones) in resource use and would "keep options open" for future generations
- such strategies are especially important for resources with extremely limited or no substitutes and which are characterized by significant consumer surplus and the existence of considerable option demand

[from Marty, 1975; -- comprehensive analysis]
"There has been a growing awareness among resource economists, and others, that decisions in the public realm are not based solely on considerations of economic efficiency. Financial analysis systems, such as benefit-cost analysis, do not provide enough information on other relevant characteristics of alternatives. Financial analysis alone is both incomplete and biasing, in that non-financial characteristics of alternatives are either ignored entirely or treated only with regard to their effects on economic welfare."

"Needed, particularly in public forestry, is an analytical process which provides appraisals of alternatives from more than one point of view. Benefit-cost analysis looks predominantly at the financial dimension of alternatives; environmental impact analysis looks primarily at the physical influence of alternatives on environmental parameters; what might be called comprehensive analysis should look at both these characteristics of alternatives, and at others as is appropriate."

"The characteristics of alternatives that most concern us are dictated by the objectives being sought. Public forest management objectives change with time and location, sometimes one and

then another objective being paramount. In some circumstances special and unusual analyses may be required. Ordinarily, however, seven characteristics of alternatives are most important."

"In general, contemplated actions must be congruent with established forest policy. Legal authorization must exist for contemplated actions, and they must also provide benefits or changes identified as unmet needs or demands in local, regional, or national appraisals. And they must correspond to land-use capabilities as identified by land-use planning on the recommending unit. In unusual circumstances, actions transcending established agency policy may be considered."

"Environmental effects include the effects of contemplated actions on basic ecological stability, on air and water quality, and upon the physical productive potential of the resource system. "

"In general, contemplated actions should be designed to be neutral or beneficial in their environmental effects. This, however, may not always be possible, and a detrimental environmental effect may not necessarily preclude an action if there are compensating benefits."

"Contemplated actions should have the characteristic of economic efficiency in the sense that benefits outweigh costs. Also, actions should be designed at an efficient scale, and the most efficient means or technology should be utilized. A program or project other than that which is most efficient is not necessarily precluded if it is superior from other points of view."

"External impacts are both positive and negative effects of a contemplated action which fall on households, businesses, and government units other than the managing agency. For example, some actions may impose a cost on a unit of local government or create additional jobs and income for local business and workers. External impacts may be primarily economic or they may relate to health and safety, environmental endowment, or others. In general, contemplated actions should be designed to minimize detrimental external impacts unless amply compensated by other benefits."

"In general, contemplated actions should be designed to benefit the many rather than the few, and those who are to benefit should bear an appropriate share of the cost. Particular attention should be paid to insuring reasonably equal access to services and benefits for all interested citizens. However, inequitable distributional effects may not necessarily preclude and action if there compensating benefits."

"It is often crucial to know the degree of risk or uncertainty associated with various alternatives. In general, contemplated actions should be designed so that the risk of an unacceptable result is held to a reasonably low level. In some circumstances, however, a higher than normal risk of failure may be justified by other favorable characteristics. And in some cases the program may be a government activity because it is too uncertain to qualify as a private venture."

"Contemplated actions should be designed at a scale which makes the actions feasible under existing budget and personnel expectations for the recommending unit. Each public forest is in competition with others for available funding, which is distributed in part on the basis of the merit and urgency of recommended projects and programs. However, unusually costly or comprehensive actions are not necessarily precluded if their benefits are correspondingly great."

"These seven parallel or collateral criteria, then, are generally of interest in choosing among public forest project and program alternatives: the degree of policy congruence, the nature of environmental effects, the degree of economic efficiency, external impacts on households,

businesses and units of government, the distribution of costs and benefits, the degree of uncertainty and their feasibility with regard to budget and personnel limitations."

[from Schuster, 1980; – distributional consequences]
"Evaluation of the distributional consequences of forestry projects is an important component in an overall assessment of the desirability of one project relative to another. But it is not the only component and there is no reason to believe it the most important component. Clearly, many other consequences are also important, including economic efficiency consequences and environmental quality consequences. The role and importance of distributional consequences in selecting between alternative forestry projects is a function of the decision-maker's goals and objectives. These not only provide the context for distributional analyses, but they also specify the content of the analysis.

"...each analysis is different, tailor-made to the specific circumstance being evaluated. While the range of items to be evaluated in a distributional analysis is almost limitless, the impacts evaluated must be limited for very practical reasons of time and money. The analyst must translate the needs of the decision-maker into operational analyses. ...Initial study results must be interpreted and evaluated with the context of the social and economic structure of the local economy in mind. The response to a given set of distributional consequences will vary from one economy to another.

[editors]
Schuster's paper calls for the evaluation of distributional consequences of forestry projects in four main areas; a) impacts on economic activity, b)impacts on individual welfare, c)impacts on economic equilibrium, and d) impacts on local government. But these areas cannot be measured directly. Each area must be defined in terms of something that can be measured, and in specific units of measurement

- Impacts on economic activity should be measured in terms of aggregate, net change in economic activity associated with the production process. Both primary (associated with primary consumers of timber) and secondary impacts are measured, using either "economic base" or "interindustry (input-output)" methods of analysis. Commonly evaluated indicators include employment levels, payroll and wage levels, value added and sales levels.
- Impacts on individual welfare involve measurements on the "quality of economic life" - as opposed to the "quantity of economic life". Indicators of individual welfare commonly include unemployment rates, average wage rates, and income re-distribution.
  Impacts on income equilibrium or stability are measured with two broad indicators ; economic diversity, and community adjustments in terms of lifestyle, social disorganization and local values.
- Impacts on local government cold involve a number of changes related to the implementation of a forestry project, but of prime importance are revenues and expenditures. One measure of such impact is the amount of intergovernmental payments, which involves the transfer of funds between different levels of government such as FRDA funding of forestry activities. Another indicator is the cost to local government that is incurred as a direct result of the implementation of a forestry project. For instance, forestry activity may require a higher standard of road construction and maintenance than would be needed without it.

To summarize, analysis of distributional consequences is a process that is strongly influenced by the objectives of the decision-maker, and is technically demanding of the analyst. As can be seen from the above brief descriptions of indicators used, it is not as simple (for example) as just calculating the number of man-months of employment to be created by a stand spacing project. One must have considerable experience in using social and economic data if one is to produce meaningful comparisons of the consequences of different alternatives.

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